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(54) Coding apparatus, coding method, and coding system

(57) A first prediction unit (101) performs intra-prediction of an original image corresponding to an inter-frame coded frame to produce a first prediction residual and a prediction parameter. A second prediction unit (102) performs intra-prediction of local decode data corresponding to the inter-frame coded data with the prediction parameter to produce a second prediction residual. A subtractor (15) calculates difference data between the first prediction residual and the second prediction residual. A third prediction unit (201) performs intra-prediction of data corresponding to a decoded frame with the prediction parameter to produce a third prediction residual, when the inter-frame coded data is decoded and transformed into the intra-frame coded data. An adder (23) calculates addition data of the third prediction residual and the differential data. An intra-frame coding unit (202) performs intra-frame coding to the addition data.

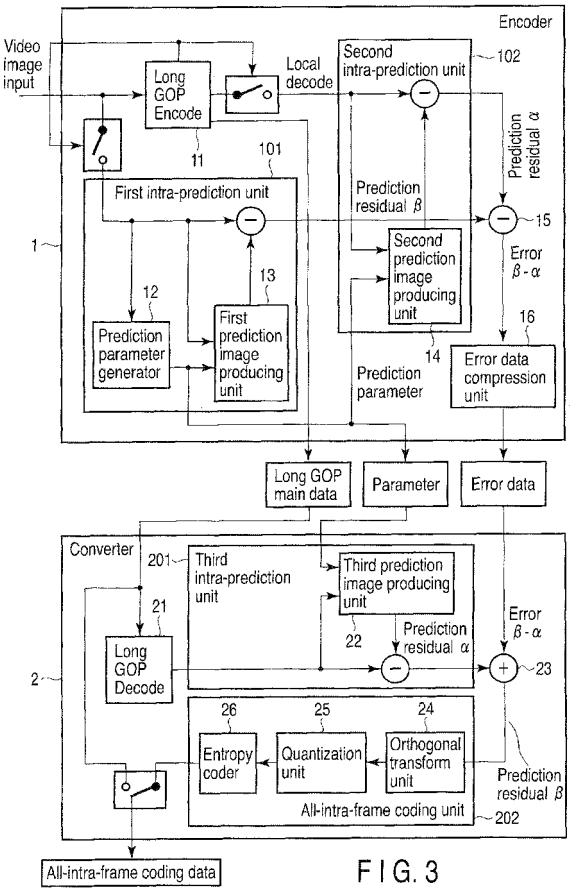

FIG. 3

EP 2 063 645 A1

Description

[0001] The present invention relates to a coding apparatus which performs coding by switching between intra-frame coding and inter-frame coding, a coding method, and a coding system.

[0002] Intra-frame coding in which intra-frame prediction is utilized and inter-frame coding in which inter-frame prediction is utilized are used as a technique of performing compression coding of moving image data. In the intra-frame coding, a difference between pixels adjacent to each other in a frame is obtained to perform coding, thereby compressing the moving image data. In the inter-frame coding, a high correlation between continuous frames is used to obtain a difference between preceding and subsequent frames of a coding object frame, and coding is performed to compress the moving image data. A high compression rate and image quality can be realized by switching between the two coding techniques according to the frame.

[0003] However, because the frame cannot be reproduced alone in the inter-frame coding, video images are hardly trimmed or combined in frame unit during editing. There is also generated a problem in special reproduction such as fast-forward and reverse reproduction in searching for an editing point. The image quality is deteriorated, when the inter-frame coding data is further transformed into an All-Intra-frame coding moving image in order to perform the editing in frame unit. When the editing is abandoned in frame unit to perform the editing in GOP (Group of Picture) unit, inter-frame coding data is hardly dealt with because a degree of freedom is lowered. When only the All-Intra-frame coding is used from the time of recording, a recording time in medium is shortened because of the low compression rate.

[0004] For example, Jpn. Pat. Appln. KOKAI Publication Nos. 2000-312362 and 8-265694 discloses associated techniques.

[0005] In accordance with an aspect of the invention, there is provided a coding apparatus which codes moving images having a plurality of frames by switching between intra-frame coding and inter-frame coding. The apparatus performs intra-prediction of an original image corresponding to the inter-frame coded frame to produce a first prediction residual and a prediction parameter; performs intra-prediction of decode data of the inter-frame coded frame with the prediction parameter to produce a second prediction residual; calculates difference data between the first prediction residual and the second prediction residual; performs intra-prediction of data corresponding to a decoded frame with the prediction parameter to produce a third prediction residual when the inter-frame coded data is decoded and transformed into the intra-frame coded data; calculates addition data of the third prediction residual and the differential data; and performs intra-frame coding of the addition data.

[0006] According to another aspect of the invention, there is provided a coding method of coding moving images having a plurality of frames by switching between intra-frame coding and inter-frame coding, the method comprising: performing intra-prediction of an original image corresponding to the inter-frame coded frame to produce a first prediction residual and a prediction parameter; performing intra-prediction of decode data of the inter-frame coded frame with the prediction parameter to produce a second prediction residual; computing difference data between the first prediction residual and the second prediction residual; performing infra-prediction of data corresponding to the decoded frame with the prediction parameter to produce a third prediction residual when the inter-frame coded data is decoded and transformed into the intra-frame coded data; computing addition data of the third prediction residual and the differential data; and performing intra-frame coding of the addition data.

[0007] According to another aspect of the invention, there is provided a coding system comprising: a coding apparatus which codes moving images having a plurality of frames to produce first coding data by switching between intra-frame coding and inter-frame coding; and a transform apparatus which performs intra-frame coding to all the frames of the first coding data to transform the first coding data into second coding data, wherein the coding apparatus includes: a first prediction unit which performs intra-prediction of an original image corresponding to the inter-frame coded frame in the first coding data to obtain a first prediction residual and a prediction parameter; a second prediction unit which performs intra-prediction of a decode image of the inter-frame coded frame in the produced first coding data with the prediction parameter to produce a second prediction residual; a subtractor which calculates a difference between the first prediction residual and the second prediction residual in each frame as error data; and an output unit which outputs the first coding data, prediction parameter and error data, and the transform apparatus includes: an input unit into which the first coding data, prediction parameter and error data output from the coding apparatus are input; a decoding unit which decodes the inter-frame coded frame in the first coding data; a third prediction unit which performs intra-prediction to the decoded frame with the prediction parameter to produce a third prediction residual; an adder which calculates addition data by adding the third prediction residual to the error data in each frame; and a coding unit which performs intra-frame coding of the addition data into second coding data.

[0008] The invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

FIG. 1 shows a frame configuration of Long-GOP data;

FIG. 2 shows a frame configuration of All-Intra-frame data;

FIG. 3 is a block diagram showing a configuration of a coding system according to an embodiment of the

invention;

FIG. 4 is a flowchart showing an encoder processing procedure;

FIG. 5 is a flowchart showing a converter processing procedure;

FIG. 6 shows a change in image quality in a transform performed by a conventional coding method; and

FIG. 7 shows a change in image quality in the coding system of the embodiment.

[0009] An embodiment of the invention will be described in detail below with reference to the drawings.

[0010] A configuration of coding data dealt with in a coding system according to an embodiment of the invention will be described. FIG. 1 shows a frame configuration of general Long-GOP data. FIG. 2 shows a frame configuration of All-Intra-frame data.

[0011] As shown in FIG. 1, frames constituting GOP include three kinds of frames, that is, an I Flame (Intra-coded Flame), a P Flame (Predictive-coded Flame), and a B Flame (Bidirectional-coded Flame). At least one I Flame is included in each GOP in order to impart independence. The I Flame is similar to one frame of the All-Intra-frame configuration of FIG. 2, and the I Flame can be reproduced alone. On the other hand, the P Flame is the one to which the inter-frame coding is performed. In general coding of the P Flame, using another image as a reference frame, pattern matching is performed to detect motion while the P Flame is divided into blocks, and prediction image data is produced to obtain a difference with an input image. The B Flame is also the one to which the inter-frame coding is performed. In the B Flame, two images are used as the reference frame.

[0012] In decoding Long-GOP, because the frame which has been used as the reference frame is required, the frame cannot simply be trimmed or combined in locations except for the I Flame. In the case where the reproduction is displayed every second frame such as double-speed reproduction, it is necessary to decode the reference frame in addition to the display frame. In the case of the reverse reproduction, it is necessary that the reproduction be reproduced from a final frame of GOP after one GOP is decoded from the I Flame which becomes separation of GOP. Because an operation response becomes significant during the editing, Long-GOP is not suitable to the editing time, so Long-GOP is often transformed such that the reproduction can be performed in frame unit from anywhere like the All-Intra-frame configuration of FIG. 2. In the case of an H. 264/AVC standard whose application is recently being increased, there is no regularity in selecting the reference frame, and an algorithm which can be edited by utilizing the regularity is hardly developed unlike MPEG2.

[0013] Therefore, in the coding system of the embodiment, the Long-GOP data can be transformed into the All-Intra-frame data without deteriorating the image quality even in the H.264/AVC standard in which the regularity does not exist in selecting the reference frame.

[0014] FIG. 3 is a block diagram showing a configuration of a coding system according to the embodiment of the invention. The coding system includes an encoder 1 and a converter 2. The encoder 1 codes an input video image into Long-GOP data during the recording, and records the Long-GOP data in a recording medium. When the Long-GOP data is taken in an editing device, the converter 2 transforms the Long-GOP data recorded in the recording medium into an All-Intra-frame format in which a correlation between frames is not used.

[0015] The encoder 1 includes a Long-GOP coding unit 11, a first intra-prediction unit 101, a second intra-prediction unit 102, a subtractor 15, and an error data compression unit 16. The first intra-prediction unit 101 includes a prediction parameter generator 12, and a first prediction image producing unit 13. The second intra-prediction unit 102 includes a second prediction image producing unit 14. The Long-GOP coding unit 11 codes the input image to store the coded image in the recording medium. Examples of the recording medium include a flash memory cartridge, a hard disk, and a writable optical disk.

[0016] In the coding performed by the Long-GOP coding unit 11, the input image is supplied to the first intra-prediction unit 101 while the frame is not the I Flame. The prediction parameter generator 12 determines a prediction parameter of the input image, and the first prediction image producing unit 13 performs the intra-frame coding to the input image. A Long-GOP local decode result, which is produced in the coding performed by the Long-GOP coding unit 11 when the frame is not the I Flame, is supplied to the second intra-prediction unit 102, and the second prediction image producing unit 14 performs the intra-frame coding the Long-GOP local decode result.

[0017] At this point, it is necessary that the coding be performed with the same coding parameter in the first prediction image producing unit 13 and the second prediction image producing unit 14. For example, in the case where the coding method is pursuant to the H.264/AVC standard, the coding parameter includes a macro block type, an intra-prediction direction, a transform method, and pattern information on a coded block. The data supplied from the first prediction image producing unit 13 and second prediction image producing unit 14 depends on the coding parameters. In the intra-frame coding processing, prediction data is produced from neighboring pixels in each block having a variable size such as 4-by-4, 8-by-8, and 16-by-16, the prediction data is compared to the input pixel to obtain a difference, and orthogonal transform, quantization, and entropy coding are performed to the difference. In the embodiment, the subtractor 15 calculates the difference between outputs from the two prediction image producing units as error data, and supplies the error data along with the prediction parameter at that time. The output comparison in the encoder 1 is performed before the orthogonal transform and quantization performed in the usual intra-frame coding

processing and the entropy coding of CABAC (Context Adaptive Binary Arithmetic Coding) or CAVLC (Context Adaptive Variable Length Coding). This enables a processing load to be reduced.

[0018] Because a data amount is increased in the case of error data having a large size, the error data compression unit 16 performs adjustment to reduce a coding amount by techniques such as the orthogonal transform, the quantization, and the entropy coding. Because the image quality is slightly lowered by the adjustment, it is necessary that a quantization step for determining the compression rate be set within a range which is allowable by an application. A usual image compression method can be applied because the error data is a kind of the image. The compressed error data is recorded in the recording medium along with Long-GOP main data.

[0019] On the other hand, the converter 2 includes a Long-GOP decoding unit 21, a third prediction image producing unit 201, an adder 23, and an all-intra-frame coding unit 202. The third prediction image producing unit 201 includes a third prediction image producing unit 22. The all-intra-frame coding unit 202 includes an orthogonal transform unit 24, a quantization unit 25, and an entropy coder 26.

[0020] The converter 2 takes in the Long-GOP main data, the prediction parameter, and the error data through the recording medium. The converter 2 reads the Long-GOP main data. The converter 2 flips a switch to directly supply the I Flame when the Long-GOP main data is the I Flame, and the Long-GOP decoding unit 21 decodes the Long-GOP main data when the Long-GOP main data is a frame except for the I Flame. The decoded data is supplied to the third prediction image producing unit 201. The third prediction image producing unit 22 produces an intra-prediction image from decode result of the Long-GOP decoding unit 21 according to the prediction parameter.

[0021] Before the orthogonal transform, the quantization, and the entropy coding are performed, the adder 23 adds the error data to a prediction residual in which a difference between the intra-prediction image produced by the third prediction image producing unit 22 and the decode result of the Long-GOP decoding unit 21 is calculated. The post-addition data is equal to the prediction residual to which the encoder directly performs the All-Intra-frame coding when the error data coding amount is adjusted by a lossless (reversible) method. The all-intra-frame coding unit 202 transforms the result into the All-Intra-frame data for editing by performing the orthogonal transform, the quantization, and the entropy coding through the orthogonal transform unit 24, the quantization unit 25, and the entropy coder 26.

[0022] An operation of the coding system of the embodiment will be described below.

(Encoder)

[0023] FIG. 4 is a flowchart showing an encoder processing procedure. The Long-GOP coding unit 11 codes the input image into the Long-GOP data and supplies the Long-GOP data (Step S4a). Each frame of the Long-GOP data is determined whether or not the frame is the intra-frame coding (Step S4b). When the frame is the intra-frame coding, the coding data is directly supplied.

[0024] When the frame is the inter-frame coding in Step S4b, an original image corresponding to the frame is supplied to the first irtra-prediction unit 101. The prediction parameter generator 12 determines the prediction parameters such as the intra-prediction direction and the block. The first prediction image producing unit 13 performs the All-Intra-frame coding to the original image using the determined prediction parameter (Step S4c). The first intra-prediction unit 101 produces a prediction residual β which is the difference between the input image and the intra-prediction image of the first prediction image producing unit 13. As shown in FIG. 3, the All-Intra-frame coding is only part of the usual All-Intra-frame coding. The orthogonal transform, the quantization, and the entropy coding are omitted. The prediction parameter determined by the prediction parameter generator 12 is stored in the recording medium.

[0025] When the frame is the inter-frame coding in Step S4b, the local decode output (identical to the Long-GOP decode result, the decode result is diverted because the encoder has a mechanism in which the decoding is always performed) of the Long-GOP coding unit 11 is supplied to the second intra-prediction unit 102. The second prediction image producing unit 14 performs the All-Intra-frame coding the Long-GOP decode result using the prediction parameter determined by the prediction parameter generator 12 (Step S4d). The second intra-prediction unit 102 generates a prediction residual α which is a difference between the Long-GOP decode result and the intra-prediction image of the second prediction image producing unit 14.

[0026] The prediction residual β supplied from the first intra-prediction unit 101 and the prediction residual α supplied from the second intra-prediction unit 102 are supplied to the subtractor 15. The subtractor 15 calculates a difference β-α between the two prediction residuals α and β (Step S4e). When the prediction residuals α and β are the same, "no error" is supplied (Step S4g). When the prediction residuals α and β are not the same, the difference β-α is set at the error data.

[0027] The error data compression unit 16 compares the error data coding amount to a target value (Step S4h). When the error data coding amount exceeds the target value, processing for adjusting the coding amount is performed by the compression processing or the like (Step S4i). For example, an error allowable range of the differential data is adjusted such that the total of the error data amount and the Long-GOP data amount does not exceed the data amount in the case where the intra-frame coding is performed to the original moving image. The error data is supplied (Step S4j), and the above-described process-

ing is repeated every one frame until an end request is provided (Step S4k).

(Converter)

[0028] FIG. 5 is a flowchart showing a processing procedure of the converter 2. The converter 2 takes in the Long-GOP main data, the prediction parameter, and the error data through the recording medium. The coding mode of the taken-in Long-GOP is checked in each frame (Step S5a). When the frame is not the I Flame, the Long-GOP decoding unit 21 performs the decoding (Step S5b). When the frame is the I Flame, the frame is directly supplied (Step S5f).

[0029] The decoded frame is supplied to the third intra-prediction unit 201, and the third prediction image producing unit 22 codes the decoded frame into the intra-prediction image using the taken-in prediction parameter (Step S5c). When the error data exists in Step S5d, the adder 23 adds the error data β-α to the prediction residual α between the intra-prediction image and the Long-GOP decode result (Step S5e). The case in which the error data does not exist in Step S5d indicates no difference between the case in which the All-Intra-frame coding is performed to the original image and the case in which the All-Intra-frame coding is performed again after the Long-GOP data is coded. The all-intra-frame coding unit 202 performs the All-Intra-frame coding to the obtained prediction residual β by the orthogonal transform, the quantization, and the entropy coding and supplies the All-Intra-frame coding data to end the processing for one Flame (Step S5f). The processing is repeated in each frame until the end request is provided (Step S5g).

[0030] The effect of the moving image coding transform system of the embodiment will be described below.

[0031] FIG. 6 shows a change in image quality in a transform performed by a conventional coding method. In FIG. 6, a horizontal axis indicates image quality of an original image, image quality during the recording, and image quality during the editing from the left side, and a vertical axis indicates that the image quality becomes better toward the upward direction. FIG. 6 shows two graphs, that is, the case in which Long-GOP is used during the recording while the data is transformed into the All-Intra-frame coding during the editing and the case in which the All-Intra-frame coding is used from the receding to the editing. In the case of Long-GOP, although the image quality is better than that of the All-Intra-frame coding during the recording, the image quality is deteriorated by the transform during the editing. Such transforms are frequently performed in currently commercially available editing software.

[0032] FIG. 7 shows a change in image quality in the coding system of the embodiment. As shown in FIG. 7, the image quality deterioration caused by the transform can be restrained even if the data is transformed from Long-GOP into the All-Intra-frame coding. Advantageously, compared with the conventional technique, the good image quality can be maintained during both the recording and editing only by the Long-GOP data and auxiliary less data (prediction parameter and error data).

[0033] Thus, in the embodiment, the difference between the data in which the intra-frame coding is performed to the reproduction image of the inter-frame coding data and the data in which the intra-frame coding is performed to the original image is retained, in addition to the coding data in which both the intra-frame coding and the inter-frame coding are used, and the intra-frame coding is performed during the editing using the differential data. Therefore, the editing can be performed using a material having the image quality equivalent to the image in which the intra-frame coding is performed to the original moving image. The error allowable range of the differential data can be adjusted such that the total of the differential data amount and the compression coding data amount does not exceed the data amount in the case where the intra-frame coding is performed to the original moving image.

[0034] Accordingly, in the embodiment, the data to which the inter-frame coding is performed can be transformed into the intra-frame coding data while the image quality is maintained.

Claims

1. A coding apparatus which codes moving images having a plurality of frames by switching between intra-frame coding and inter-frame coding, the apparatus **characterized by** comprising:

   a first prediction unit (101) which performs intra-prediction of an original image corresponding to the inter-frame coded frame to produce a first prediction residual and a prediction parameter;
   a second prediction unit (102) which performs intra-prediction of decode data of the inter-frame coded frame with the prediction parameter to produce a second prediction residual;
   a subtractor (15) which calculates difference data between the first prediction residual and the second prediction residual;
   a third prediction unit (201) which performs intra-prediction of data corresponding to a decoded frame with the prediction parameter to produce a third prediction residual when the inter-frame coded data is decoded and transformed into the intra-frame coded data;
   an adder (23) which calculates addition data of the third prediction residual and the differential data; and
   an intra-frame coding unit (202) which performs intra-frame coding of the addition data.

2. The apparatus according to claim 1, **characterized by** further comprising an adjustment unit (16) which

adjusts a data size of the differential data.

3. A coding method of coding moving images having a plurality of frames by switching between intra-frame coding and inter-frame coding, the method **characterized by** comprising:

performing intra-prediction of an original image corresponding to the inter-frame coded frame to produce a first prediction residual and a prediction parameter;
performing intra-prediction of decode data of the inter-frame coded frame with the prediction parameter to produce a second prediction residual;
computing difference data between the first prediction residual and the second prediction residual;
performing intra-prediction of data corresponding to the decoded frame with the prediction parameter to produce a third prediction residual when the inter-frame coded data is decoded and transformed into the intra-frame coded data;
computing addition data of the third prediction residual and the differential data; and
performing intra-frame coding of the addition data.

4. The method according to claim 3, **characterized by** further comprising adjusting a data size of the differential data.

5. A coding system **characterized by** comprising:

a coding apparatus (1) which codes moving images having a plurality of frames to produce first coding data by switching between intra-frame coding and inter-frame coding; and
a transform apparatus (2) which performs intra-frame coding to all the frames of the first coding data to transform the first coding data into second coding data,

wherein the coding apparatus (1) includes:

a first prediction unit (101) which performs intra-prediction of an original image corresponding to the inter-frame coded frame in the first coding data to obtain a first prediction residual and a prediction parameter;
a second prediction unit (102) which performs intra-prediction of a decode image of the inter-frame coded frame in the produced first coding data with the prediction parameter to produce a second prediction residual;
a subtractor (15) which calculates a difference between the first prediction residual and the second prediction residual in each frame as error data; and
an output unit which outputs the first coding data, prediction parameter and error data, and

the transform apparatus (2) includes:

an input unit into which the first coding data, prediction parameter and error data output from the coding apparatus are input;
a decoding unit (21) which decodes the inter-frame coded frame in the first coding data;
a third prediction unit (201) which performs intra-prediction to the decoded frame with the prediction parameter to produce a third prediction residual;
an adder (23) which calculates addition data by adding the third prediction residual to the error data in each frame; and
a coding unit (202) which performs intra-frame coding of the addition data into second coding data.

6. The coding system according to claim 5, **characterized in that** the coding apparatus further includes an adjustment unit (16) which adjusts a data size of the differential data.

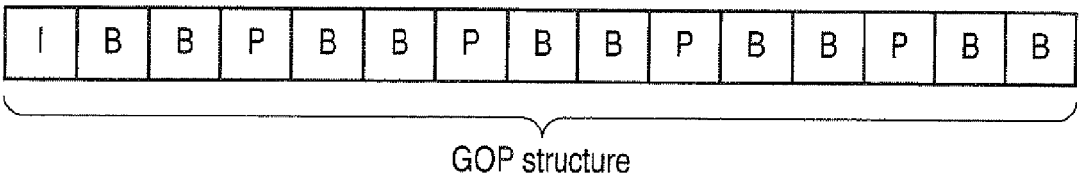

FIG. 1

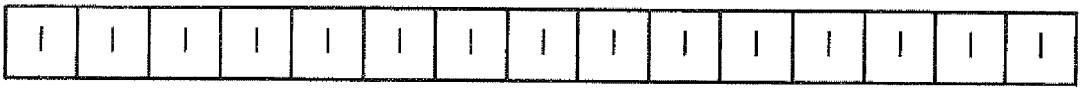

FIG. 2

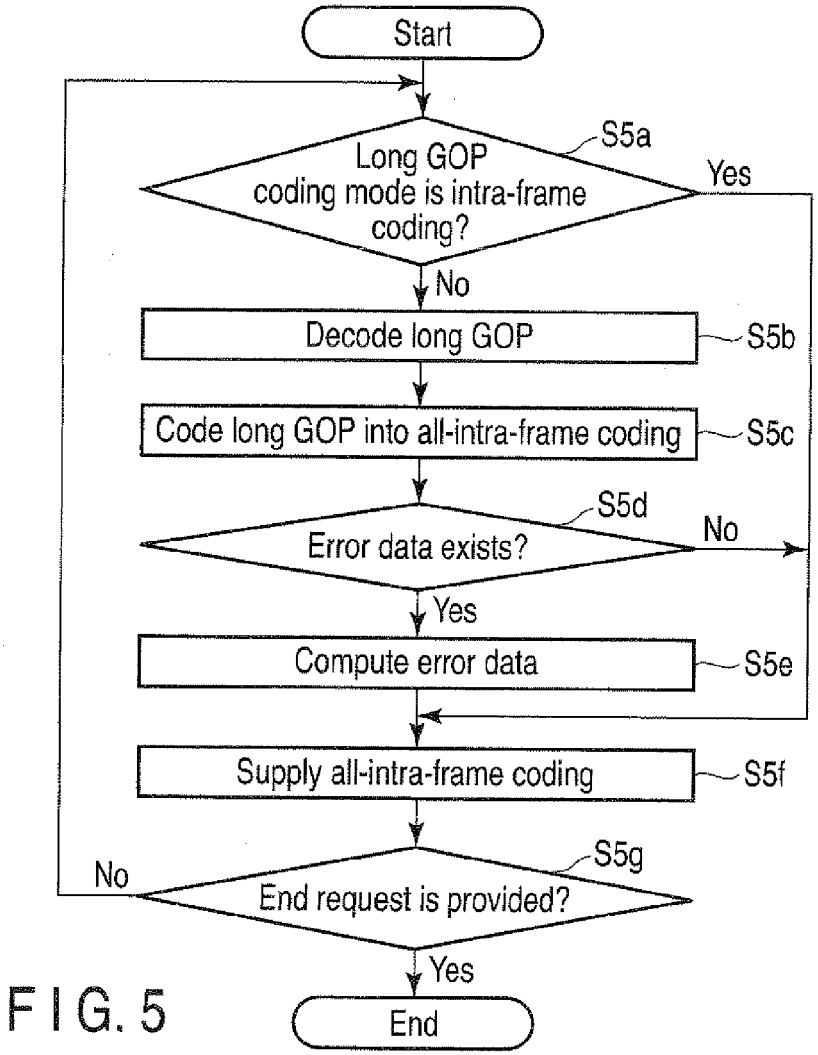

FIG. 5

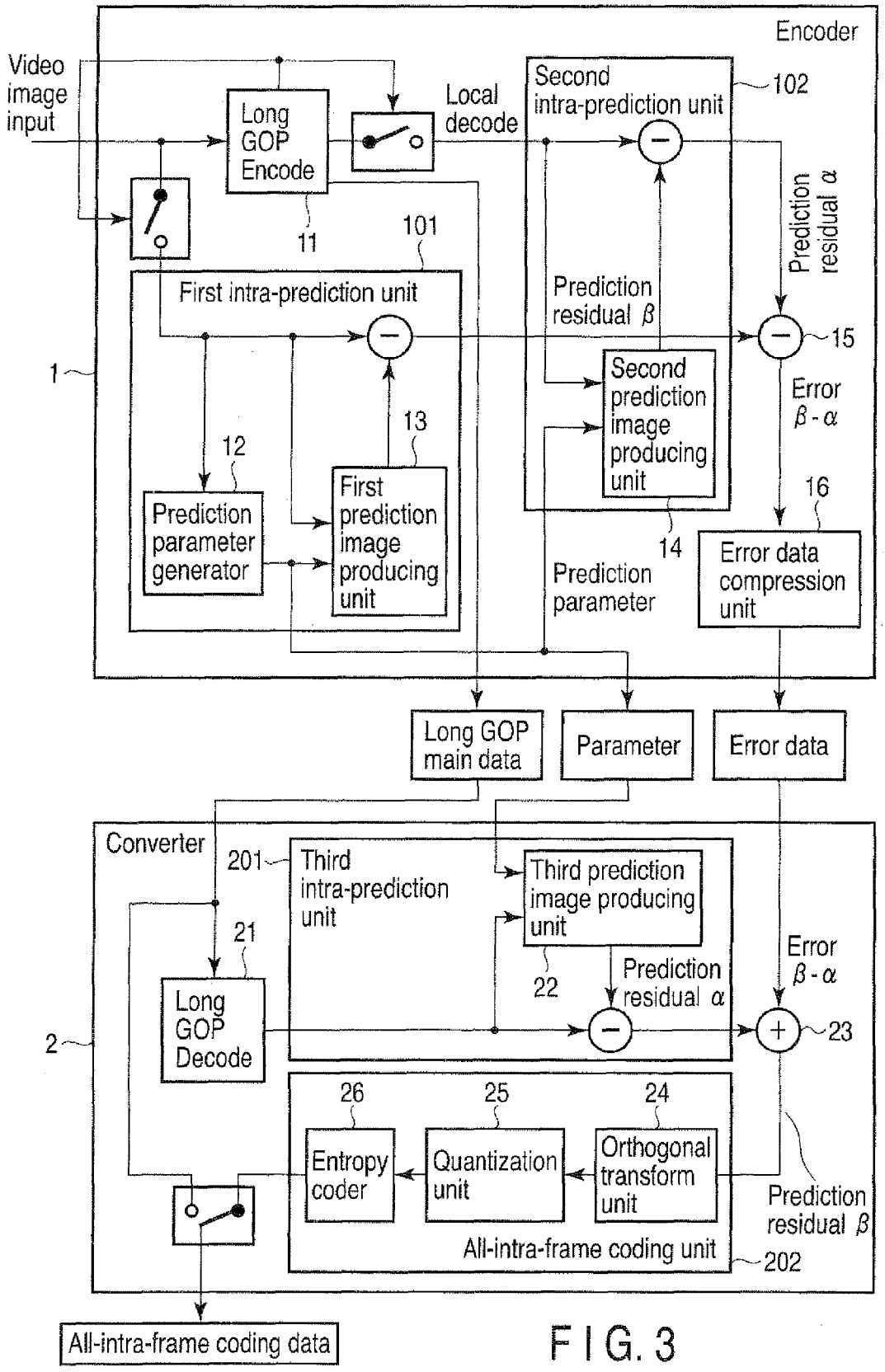
Encoder
Video image input
Long GOP Encode
11
Local decode
Second intra-prediction unit
102
Prediction residual α
101
First intra-prediction unit
Prediction residual β
15
1
Second prediction image producing unit
Error β - α
13
12
16
Prediction parameter generator
First prediction image producing unit
14
Error data compression unit
Prediction parameter
Long GOP main data
Parameter
Error data
Converter
201
Third intra-prediction unit
Third prediction image producing unit
21
Error β - α
22
Prediction residual α
Long GOP Decode
2
23
26
25
24
Entropy coder
Quantization unit
Orthogonal transform unit
Prediction residual β
All-intra-frame coding unit
202
All-intra-frame coding data

FIG. 3

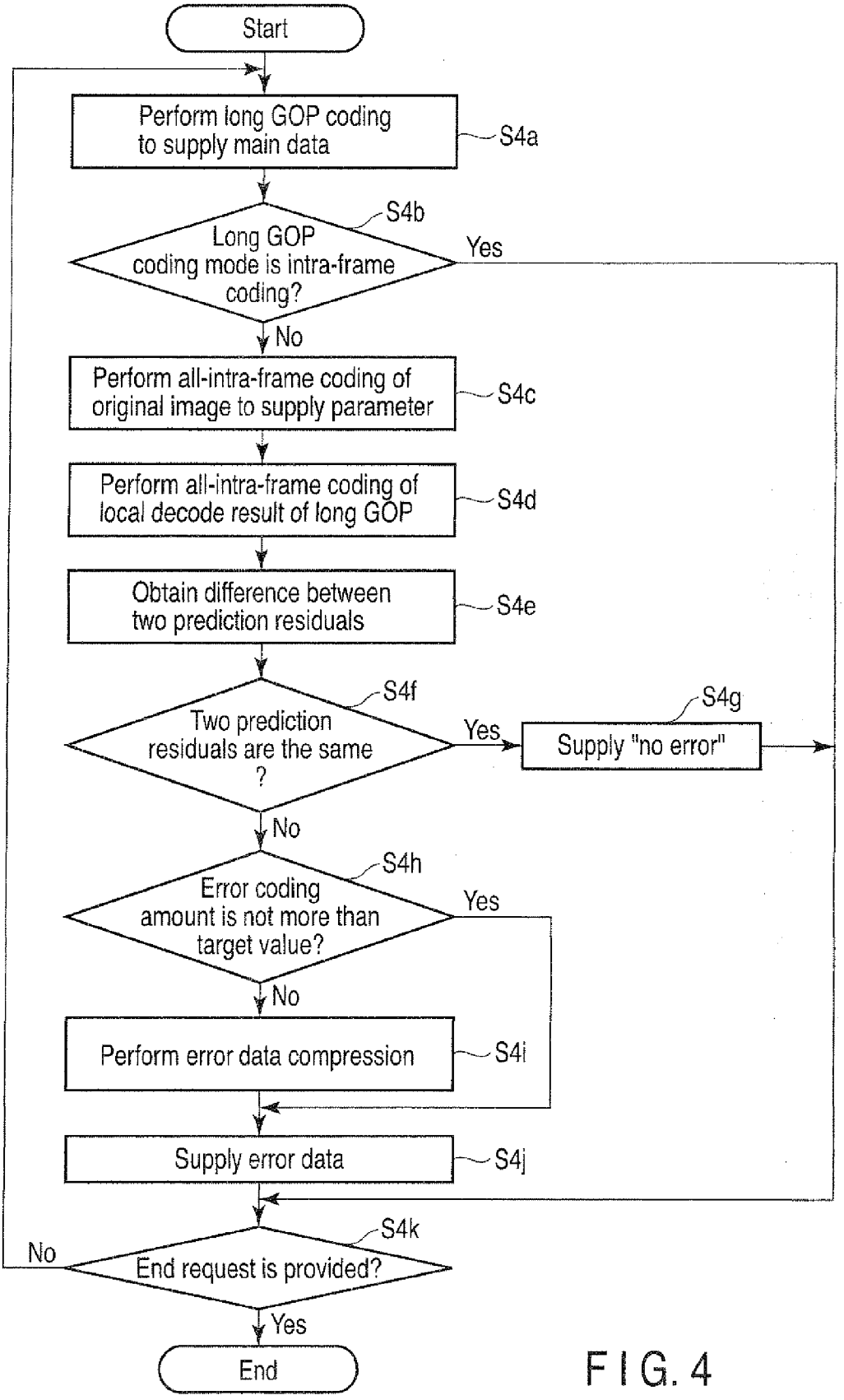
Start
Perform long GOP coding to supply main data
S4a
Long GOP coding mode is intra-frame coding?
S4b
Yes
No
Perform all-intra-frame coding of original image to supply parameter
S4c
Perform all-intra-frame coding of local decode result of long GOP
S4d
Obtain difference between two prediction residuals
S4e
Two prediction residuals are the same ?
S4f
Yes
Supply "no error"
S4g
No
Error coding amount is not more than target value?
S4h
Yes
No
Perform error data compression
S4i
Supply error data
S4j
End request is provided?
S4k
No
Yes
End

FIG. 4

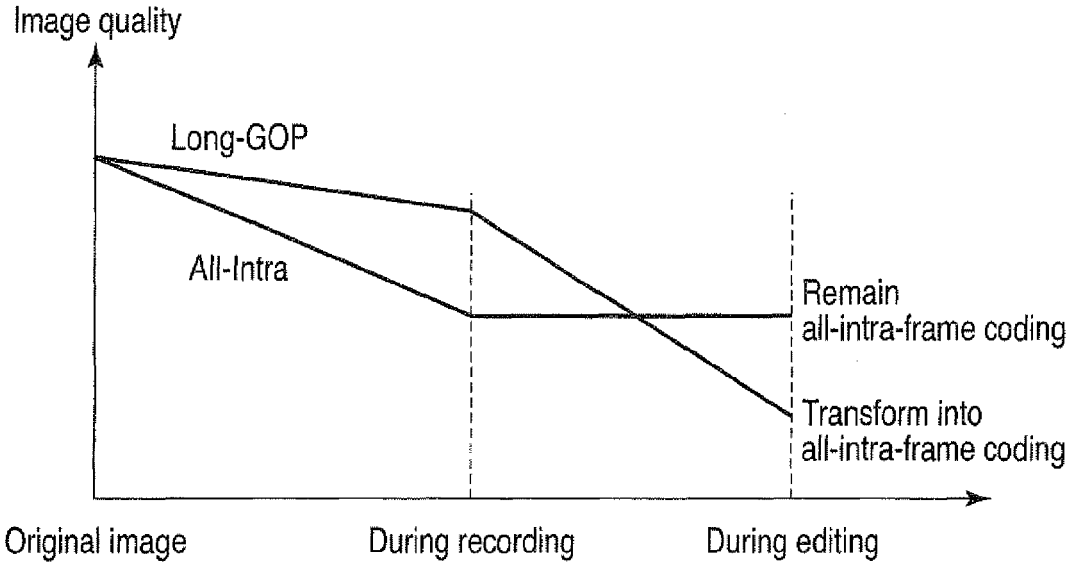
Image quality
Long-GOP
All-Intra
Remain
all-intra-frame coding
Transform into
all-intra-frame coding
Original image
During recording
During editing

FIG. 6

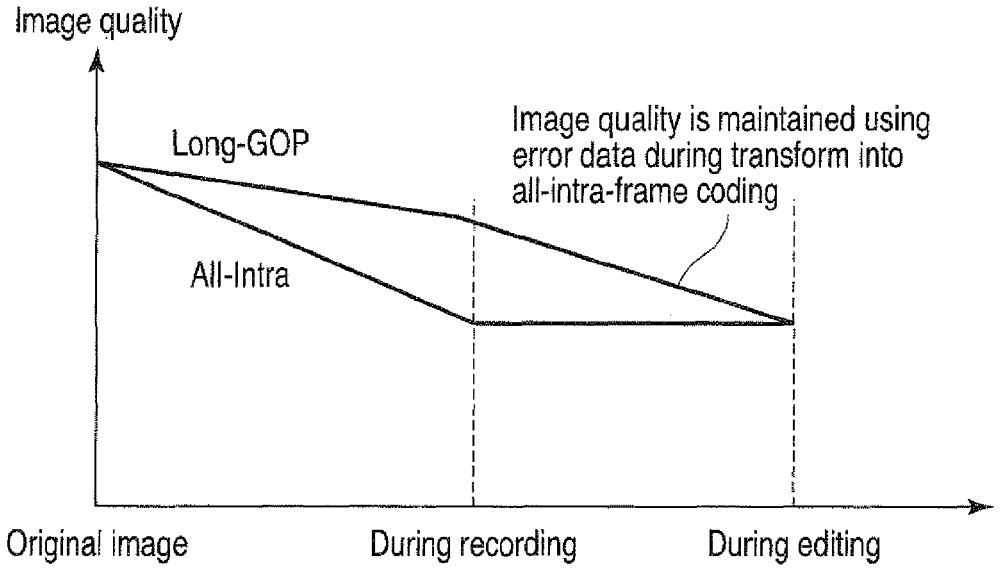
Image quality
Long-GOP
Image quality is maintained using
error data during transform into
all-intra-frame coding
All-Intra
Original image
During recording
During editing

FIG. 7

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 08 16 1808

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2007/025439 A1 (HAN WOO-JIN [KR] ET AL) 1 February 2007 (2007-02-01) * paragraphs [0013] - [0019] * * figures 8,10 *		INV. H04N7/34 H04N7/26
A	WO 2006/080779 A (SAMSUNG ELECTRONICS CO LTD [KR]; CHA SANG-CHANG [KR]; HAN WOO-JIN [KR]) 3 August 2006 (2006-08-03) * figures 6,9,10,14 * * paragraphs [0020] - [0026] *	1-6	
A	US 2007/133951 A1 (FLECCHIA MARK [US]) 14 June 2007 (2007-06-14) * the whole document *	1-6	

TECHNICAL FIELDS SEARCHED (IPC)
G11B
H04N

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	26 February 2009	Lindgren, Johan

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